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ABSTRACT

Presented are policy guidelines and recommendations intended to help administrators of engineering colleges facilitate the entry and retention of women in undergraduate programs. The report offers a summary of the status of women in undergraduate engineering programs and future trends of women in engineering schools; two mechanisms that will contribute to the success or failure of women's programs; and a set of proposals upon which administrators can act. (Author/SA)

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**WOMEN IN ENGINEERING: POLICY RECOMMENDATIONS
FOR RECRUITMENT AND RETENTION
IN UNDERGRADUATE PROGRAMS**

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This report addresses the question: What can be done by an engineering college dean to facilitate the entry and retention of women in undergraduate engineering programs? We offer policy guidelines and recommendations which, we believe, will assist engineering college administrators in achieving this end. In formulating these proposals, we have drawn on a number of resources: previous research (by ourselves and others); the guidance of an Advisory Panel, representing both researchers and practitioners in the area; and a new study just completed which has included an analysis of enrollment changes at all U.S. engineering schools between 1972 and 1976, a focussed study of thirty most-successful and thirty least-successful programs in attracting women, and an in-depth study of one rather successful program (Connolly and Porter, 1978). (A full report of this study is available from the authors.)

Drawing on this diverse body of materials, this report presents:

- A. a brief summary of the present status of, and likely future trends in, the enrollment of women in undergraduate engineering programs;
- B. what we see as the two key mechanisms underlying the success or failure of an engineering school's women-oriented programs; and
- C. a set of action proposals for engineering college administrators.

A. Present Status of Women in Undergraduate Engineering Programs

Historically, the engineering profession has attracted only tiny numbers of women. As recently as 1970, only about 1% of undergraduate engineering degrees awarded in this country went to women, with still smaller fractions receiving advanced degrees. However, since the early 1970's, this situation has been changing very rapidly (see Figure below). As of Fall 1977, women represented 10% of full-time undergraduate (FTUG) engineering students, and over 11.2% of the entering class. In actual numbers, the growth in full-time undergraduate students has been from

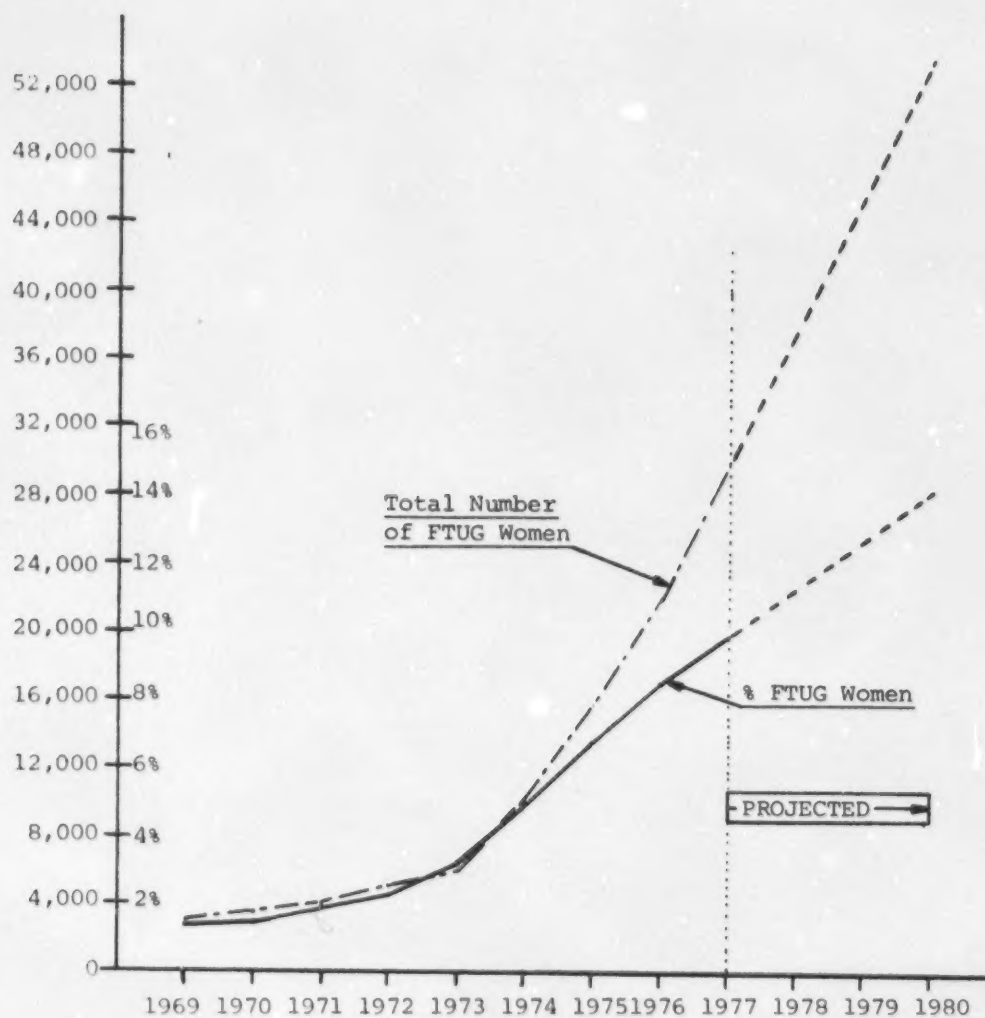


Figure 1: Total Numbers, and Percentage, of Full-Time Undergraduate (FTUG)

Women in U.S. Engineering Schools, 1969-1977

(Source: EJC/EMC, Ref.1)

around 4,000 women in Fall, 1971 to almost 22,000 (Fall, 1976) and 29,000 in Fall, 1977 (see Reference 2). Assuming this trend continues, we project about 54,000 FTUG women, roughly 14% of all FTUG engineering students in the U.S., by Fall, 1980.

This gain has not been one of numbers alone. The women now entering undergraduate engineering programs are academically very able, typically as strong as, or stronger than, their male counterparts. One researcher (Ott, 1978) reviewing a range of indicators of academic ability, concludes that "women engineering students are among the best qualified students at U.S. universities," a conclusion echoed by our own data. Further, there are indications that these women often tend toward positions of campus leadership in student government, professional honorary societies, and so on. Regardless of other possible motivations, any dean concerned with the academic quality of a school's engineering students has a thoroughly pragmatic reason for seeking women: they are excellent students.

The movement of women into engineering has not been confined to one or two areas of the country. It has, rather, been a broadly-distributed national phenomenon. For example, the Fall, 1976 national average was 8.5% women. Only four states (Maine, 4.6%; South Carolina, 4.9%; Nebraska, 4.9%; and Utah, 4.8%) fell below 5% women in their engineering schools; and only eight states exceeded 10% (Delaware, 11.4%; Pennsylvania, 10.8%; Michigan, 10.5%; Georgia, 10.4%; Tennessee, 10.8%; Missouri, 10.6%; Montana, 10.6%; and Nevada, 10.4%). The trend, then, is geographically widespread; and state-to-state variance is modest.

The school-to-school differences, in contrast, are quite large. Again using 1976 data, the ten most successful schools at attracting women averaged 18.4% FTUG women; the ten least successful schools (excluding military

academies) averaged only 1.6% women. These contrasts are rather reliable over time: the 1976 "top ten" schools were well above the national average four years earlier, with 5.8% women in Fall, 1972; while the 1976 "bottom ten" schools averaged only 1.0% women in Fall 1972, well below the national average of 2.3%. This very wide difference, and the stability over time, leads us to ask: What differences between the successful and unsuccessful schools account for their differential success in attracting women? Some of the differences are relatively stable characteristics of the schools (size, location, reputation, etc.) which are not readily controllable by their administrators. Others include the range of women-oriented activities in which the school engages. Such activities are of central interest in formulating the recommendations in this report.

Two school characteristics account for a substantial part of the difference: larger schools have tended to do better than small ones, and academically or socially elite schools have outperformed less-elite schools. This is consistent with a "distinguished pioneer" mechanism, where the first wave of women entering engineering, an exceptionally gifted and geographically mobile group, were attracted to such schools. It is vital not to overemphasize these factors for, as we have noted, the enrollment of women in undergraduate engineering is growing rapidly. Consequently, suitable women students should increasingly be available to essentially all schools. What the school does, then, makes a difference in the number of women it attracts.

B. Underlying Mechanisms

We do not favor the application of simple rules to complex situations, and do not support conformist solutions to diverse circumstances - complex situations require complex rules and diverse circumstances require diverse solutions.

(Carnegie Commission on Higher Education:
Opportunities for Women in Higher Education, 1973)

As a national phenomenon, the entry of women into engineering is clearly a "complex situation." It involves multiple forces - e.g., the growing career-consciousness of women, equal opportunity pressures on schools and employers, growing job opportunities in engineering and declining opportunities in fields such as teaching, and efforts made by engineering schools and professional societies. We do not address this complex of national forces. Our focus is specifically on the individual engineering undergraduate program, and the role of the college administration in facilitating entry of women.

Women-oriented programs take a variety of forms and emphases at different schools. However, their success or failure seems to be conditioned by the extent to which they address two key underlying mechanisms. We express these as hypotheses:

1. The Decision Support Hypothesis: Women considering engineering as an undergraduate major are doing something unusual. They are unsure about what the study or practice of the profession will involve; family, friends and teachers will generally have little helpful advice; there are few women engineers with whom to talk; and the situation is changing rapidly. In short, engineering is a "high uncertainty" choice for a woman, and relatively more reassurance or "decision support" is needed to reduce this uncertainty.

The importance of support programs for women already in engineering school is documented by Davis, 1978, and others. We are here arguing for a more general hypothesis, that support is needed before entry as well as during undergraduate training. The nature of this support will vary over time and by situation. Prospective students can benefit from perception that they are welcome and will get a fair chance. New frosh need campus-oriented support; seniors, job-oriented reassurance.

2. The Positive Feedback Hypothesis: It appears that one of the most helpful factors in attracting women is to have a sizeable number already. This helps in various ways: social and academic support groups on campus, involving both peers and more advanced students (often referred to as having a "critical mass" of women students); establishing a grapevine for course and career guidance; "role models," both older students and women faculty; informal recruiting, through contact with current high school

students; attitude change, as high school and college faculty and counselors see women succeeding as engineering students; and so on.

Note that each mechanism implies possible traps for engineering college administrators. The Positive Feedback mechanism implies that "breaking in" is particularly difficult; and the Decision Support Hypothesis raises the danger that highly visible special programs for women may reinforce their perception of themselves as "unusual", with negative effects on recruitment and retention.

Situation-specific considerations are vital in interpreting the mechanisms at work. For instance, on one campus we were told that women came into engineering only after women were present in arts and sciences. At another, women perceived the relative absence of women in other fields as an advantage because they would not be subject to "unfair" social competition from women with easier course loads. These quite different situations make sense when considered in light of the two hypothesized mechanisms.

Decision Support and Positive Feedback mechanisms suggest positive actions to foster women in engineering efforts. The following are ideas that naturally require situation-specific review for their appropriateness:

- a. Public recognition of performance by women students pays off.
- b. Perceptions are all-important. Clustering women in class sections is one clever way to take advantage of reassurance in the presence of others (e.g., if one has 40 women in a frosh class of 2,000, place them all in one or two sections of introductory calculus of 100 students or so each - without making a point of it).
- c. Determine the critical mass levels and strive to attain these. One level noted was about 3 women in each class (again, clustering may help attain such thresholds).
- d. Interaction groups (such as SWE - Society of Women Engineers) may be most important when there are relatively few women present. They may also be a source of reassurance at critical points (e.g., new frosh, starting co-op students with their first harsh experiences on the job).

- e. Recruitment may likewise cluster as a result of positive feedback at work. Recruits are likely to come from certain high schools, aided by positive reports from women who are succeeding in engineering.

The following more extensive action recommendations also derive from the assumption of these two underlying mechanisms.

C. Action Recommendations

1. Take Stock

Given the explosive growth in the numbers of women entering engineering in the past few years, criteria of success become rapidly obsolete. Several of the deans we spoke to expressed satisfaction with tiny representations of women in their programs. They seem to have set goals around 1970, when 1% or so women was the national average; with a current 2-3%, they feel they are doing rather well. In fact, of course, schools with less than 10% women in their entering classes are substantially lagging the national trend - and, given the positive feedback mechanisms, are likely to remain laggards. A first step then is to reassess how well one's school is doing in recruiting women. Schools with 15-20% women may be looking for a "growth maintenance" strategy. Those substantially below this level will, in our estimation, need an intensive focussed effort for a few years to "break in" on the positive feedback loop, and then move to a growth maintenance mode.

2. Actions Needed to Break In

Schools which find themselves substantially behind the national average in enrollments of women will need a period of hard work and serious commitment to break in. In part, this is implicit in the positive feedback mechanism sketched above; in part, low representation implies that the

school may not have the facilitating characteristics (such as social or academic eliteness) noted earlier. The following elements appear important in mounting such an intensive effort:¹

- a. A careful assessment of present sources of students: In most cases, recruitment is primarily from high schools, but some engineering programs have significant recruitment from junior colleges, or of mature students. At least one program we contacted "broke in" by developing a special, intensive "second bachelors" program in engineering, recruiting women from liberal arts programs. Such careful identification of recruitment targets seems an important first step.
- b. Intensive recruiting: In addition to general information-dissemination, our findings suggest that direct contact with potential students is crucial. Direct mail and personal contact with individual students seem effective; wide, thin recruiting (e.g. brochures) seems rather ineffective. Tactics used by successful programs include personal letters, telephone follow-up with prospective students, campus visits, and identifying one focal person on campus who can provide personal reassurance and help straighten out administrative hassles. Scholarships seem effective, even if the dollar value is modest, perhaps because of their reassurance value. High school visits are commonly used, particularly by schools which emphasize local recruitment (as against national recruitment). These seem most effective if they involve women engineers (faculty or current students), and if they provide an opportunity for personal discussions and good follow-on. In general, these efforts might be usefully viewed as career guidance - disseminating information on engineering as a career for the prospective student to make a better informed decision.
- c. Review existing blocks: Despite recent gains, there remains evidence of specific pressures which close off engineering to women. Some high school career counselors may still be steering women away from engineering. Inadequate mathematical preparation in high schools remains a problem. Where such specific blocks are identified, focussed efforts at remediation may be highly effective.
- d. Experiment: One of our clearest findings is that there is no "one best way" to boost enrollments of women. Successful programs are tailored to the particular school and its characteristics - the location, recruitment radius, program format, and

¹While we lack empirical support, the idea of giving someone direct responsibility to undertake a comprehensive women in engineering effort is intuitively appealing.

so on. While the experience of other schools can provide useful ideas¹, each school will have to experiment to find the most effective mix of activities for its situation.

- e. Plan comprehensively: A successful women-oriented program requires attention to the entire sequence of activities from high school preparation to choice of undergraduate major and school, to college entry, to successful performance in school, and ultimately to job placement. A "crash program" in only one of these areas (e.g. high school recruiting) may fail if other parts of the sequence are ill-prepared (e.g. residential arrangements, campus support efforts). Positive feedback exacerbates the effects of such failures. Balanced attention to each part of the sequence is required in planning for the intensive effort.

In short, an intensive effort aimed at a rapid growth in enrollments of women will require a significant commitment, and at least some experimentation to determine the most effective mix of activities for a particular school. The sources of potential women students must be carefully identified, and a recruiting strategy formulated which stresses direct personal contact with the student. Particular blocks, especially in high school counseling and math preparation, may be identified and worked on. The general goal is to move within a few years to achieving a "critical mass" of women students. From there, the school can move to a "growth maintenance" mode.

3. Growth Maintenance

Our evidence suggests that, once a program has achieved a "critical mass" in terms of women enrolled, recruiting and retention efforts become somewhat self-sustaining, and require less intensive support from the school's administration. We are not, of course, advocating that women-oriented efforts be abandoned when enrollment reaches some pre-specified

¹We will gladly provide references to those interested in what others are doing.

percentage; we are suggesting only that the intensive effort required for "breaking in" can be somewhat moderated when steady growth has been attained. Indeed, we cannot give any precise guidance as to when this point has been reached. Our statistical analyses do not clarify the point, and the deans with whom we spoke suggested several guidelines - "over 10-15%," "over a hundred total," "when there are several women in every class." Care is needed in deciding when this point has been reached in a particular program.

A "growth maintenance" mode requires attention to a number of specific matters, none individually critical, but of important cumulative effect.

These include:

- a. Maintain steady recruiting effort: As noted earlier, these efforts are greatly facilitated by having women currently in the program. Current students can be encouraged to undertake informal recruiting, on or off the campus, participate in high school visits, and so on.
- b. Integrate women into campus life: Many, perhaps most, women engineering students seek equal treatment with male students, and are suspicious of obvious women-oriented activities. For example, several deans suggested that formal "Women in Engineering" offices tended to over-emphasize the special concern for women; their functions were better placed in existing facilities (such as the Dean of Students Office). Similarly, several deans noted that women students were suspicious of women-oriented organizations such as SWE, preferring to get involved in existing chapters of professional societies oriented to their disciplines. There appears to be a rather subtle balancing act here, meeting the special needs of women students without labelling them as outside the mainstream of engineering education.
- c. Specific concerns: The physical facilities of engineering schools, designed for all-male student bodies, provide everything from minor irritants to major difficulties for women. Upgrading may be needed in housing, athletic and recreational facilities, lounges, and restrooms.
- d. Support persons: Adequate counseling (academic, career, and personal) should be made available (for both men and women). Women faculty seem potentially important as "role models" for women students. However, there are presently so few that we cannot confirm how important they actually are.

- e. Career facilitation: Women may, more than men, need help with choosing and planning their careers. In addition to career information and counseling, actual experience (in co-op programs and summer jobs) and contact with practicing women engineers seems helpful here. The next frontier in establishing the entire positive feedback chain will be successful job experience. Women need support at this stage too.
- f. Retention: Reliable evidence on retention rates for men and women is hard to come by. What there is suggests considerable variation across schools. There are indications that women are less likely to drop out, and more likely to transfer, than are men, and to have overall slightly lower retention rates. In part, this is consistent with the broader academic interests found in women engineering students. Some programs experience substantial rates of transfer, both in and out, by women students. Since these processes seem so dependent on the particular circumstances (for example, the availability of other campus resources; the level of initial commitment to an engineering major), we can offer only general advice. First, the difference between men and women in retention rates is generally quite small and not of major concern. Second, it is not the retention rate itself but its underlying causes that matter. If women are leaving because of over-recruitment or a hostile atmosphere in engineering, there are grounds for concern; well-informed reassessment of career choices, on the other hand, seems entirely desirable.

Conclusion

The representation of women in engineering is growing rapidly, a change which is only partly attributable to the efforts of individual engineering schools. Percentage representation which was outstanding five years ago is now likely to be well behind the national average. Schools which are lagging in attracting these high-quality students may need a concentrated effort to catch up. Those which are now doing well should be able to sustain their growth by somewhat less-intensive attention to a number of specific matters, with fewer resources than are needed for a concentrated "break in" program. Indications are that the growth in percentage of women in undergraduate engineering programs will continue, and that high percentages of women will soon become the norm in engineering schools. We hope the proposals offered here will facilitate the achievement of this norm.

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3. "Female Engineering Students: Attitudes, Characteristics, Responses to Engineering Education." Mary D. Ott, College of Engineering, Cornell University.
(Final Report on a large N.S.F.-sponsored project; provides careful documentation of a nation-wide sample of men and women engineering students.)
4. "Beyond Tokenism." Sandra O. Davis. New Engineer, Feb., 1978, pp. 22-29.
(Gives an interesting, "in-their-own-words" picture of men and women engineering students; documents the need for support programs.)

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